the movement, that Duchenne comes much nearer the truth than the brothers Weber, muscular action playing a much larger part than the force of gravity. Those who have watched the passive movements of a paralysed leg during attempts at progression will have no difficulty in accepting Prof. Fischer's results.

The problem of estimating theoretically the force necessary to produce the forward swing of the lower extremity in walking is an extremely complicated one. Prof. Fischer regards the lower extremity as a pendulum made up of three segments, each of which undergoes certain secondary movements during the swing of the entire extremity. Further, the hip joint, from which the pendulum is suspended, undergoes an irregular forward movement during the swing of the limb. The resistance and elasticity of the muscles and ligaments and the friction at the various joints are factors which can only be approximately estimated.

By means of photographic records Prof. Fischer was able to subdivide the forward swing into forty and forty-one equal phases of time, and by estimating the amount of force in action during each phase he shows that gravity alone can account for only a minor fraction of the force necessarily expended in the movement. Further, the positions assumed by the foot, leg, and thigh during a forward swing show distinctly that various groups of muscles are then in action. He recognises four periods in the forward movement of the limb, each of which is characterised by the action of a distinct group of muscles. In the commencing phase the ilio-psoas bends the thigh on the body, the rectus femoris extends the leg forwards, the tibialis anticus bends the foot upwards; in the second phase the gluteus maximus and hamstring muscles draw the thigh backwards; in the third phase the knee is flexed by the gastrocnemius and short head of the biceps; in the final phase the muscles in front of the leg are again in action, and remain powerfully contracted until the sole of the foot is again planted on the ground.

These results are certainly much more in keeping with clinical and everyday experience than those of the brothers Weber. Many who only occasionally take long walks must have observed that one of the first groups of muscles to give out are those in front of the leg, and that they feel painful only at the end of the forward swing, when the heel reaches the ground—the period at which Prof. Fischer shows these muscles come most powerfully into action. A. KEITH.

EARTHQUAKES.

Earthquakes. By Clarence Edward Dutton, Major, U.S.A. Pp. xxxiii+314; 63 illustrations. (London: John Murray.) Price 6*s.* net.

EPITOMISED and carefully digested accounts of seismological investigations made during the last twenty-five years are few in number. Two have been published in England, a compilation has been "made in Germany," and now we have a volume from the distinguished geologist, Major C. E. Dutton, of the United States. All told, therefore, we have only four books which give the uninitiated some idea of what the new seismology means and what it has accomplished. About the old seismology, volumes, papers, and particularly sermons exist in thousands. But if we except a few, and amongst the few the works of Mallet stand high above the rest, all they give are reiterated narratives of what people saw and heard, now and then enlivened by some wild hypothesis or pious reflection.

Major Dutton's work belongs to another category, and rather than telling us what earthquakes do, his main object has been to tell us what they are, and while doing this he has kept abreast with the work of others which his own inquiries in the domain of seismic and volcanic activities have enabled him to present in a terse and accurate form.

Everything is discussed with a minimum of mathematics from a strictly scientific standpoint, whilst that which is sensational has properly been most carefully put under taboo. A justification for the exclusion of what is of practical importance, which gives not only to the man in the street but to Governments some inkling as to the use of earthquakes, is not so apparent. It is extremely likely that a Prime Minister may not care a twopenny-bit whether the inside of the world on which he lives is red hot or stone cold, while he might be extremely interested to know that seismograms may afford a satisfactory explanation for the interruption of his cablegrams. The importance of earthquake writings to communities who have been alarmed by accounts of disasters in foreign countries is self-evident, while it would at least be consoling to those who were suddenly cut off from the outer world by the failure of their cables to learn whether such failures were the result of an operation of war or of nature. A knowledge of how to construct so that earthquake effects should be minimised means the saving of life and property in countries subject to seismic disturbances. Seismic charts indicate positions where it is dangerous to lay deep-sea cables, whilst they tell the hydrographer where he may expect to find changing depths. In these and in a variety of other directions seismology helps to make communities comfortable, and at the same time acts as incentive to create a popular interest in and to obtain support for a young science. But as Major Dutton defines his standpoint, and as a volume of 300 pages cannot contain everything, our remarks on omissions must only be taken as indications of the hydra-headed nature of seismology.

The first four chapters are chiefly devoted to the cause of an earthquake, which is defined as anything that "calls suddenly into action the elasticity of the earth." Explosions at volcanic foci produce a local trembling, but they are comparatively of rare occurrence and seldom disturb large areas. When a long fault line is produced, and a large territory carrying perhaps mountain ranges drops down along its length, instrumental observations have revealed the fact that the world may be shaken as a whole. Subsequent adjustments along such a line due to intermittent recovery from overstrain and settlements of disjointed materials give rise to numerous after-shocks which are only sensible over areas of small size, and it seems

likely that the greater number of earthquakes felt in the world belong to this latter class. All of them represent a relief of stress, and the discussion on the sources of earth stresses, commencing with the contractional hypothesis and concluding with the results of investigations by Prof. George Darwin, are attractive not only to seismologists but to all who wish to learn something about the inside of the world on which they live.

Some fifty pages are given up to descriptions of seismoscopes and seismographs, attention being particularly directed to those which record unfelt teleseismic movements. We cannot say that the concepts relating to seismic wave motion put forward are generally accepted, but such as they are we may say that they represent modern views. About the amplitudes and periods of earthquake waves seismologists have certain definite information, but about the magnitudes of these elements, particularly for waves which have travelled over long paths, much has yet to be learned. For this latter class of movement it is pointed out that discordant results are found in tables showing the speeds at which they were propagated. The author inclines to the view that the differences which have been noted are due to variability in the delicacy of instruments employed to pick up a wave or wave group. In great measure this may be true, but it seems to us that marked errors may also arise in consequence of inaccuracy in determining the time at which waves were generated at their origin.

Then, again, there are those who incline to a belief, which they sustain with arguments deserving close consideration, that within our earth convection currents exist; it would follow from this that along similar paths, or even along the same path, earthquake speeds should vary.

Notwithstanding these uncertainties, the author holds the opinion that remarkable and unexpected results which fit well within errors of observation have been reached.

Two serious difficulties, for the explanation of which we are asked to wait patiently, relate to the lengthening of wave periods and the total duration of a disturbance as it radiates. We will suggest that the former phenomenon may perhaps be at least partially explained by assuming that in the vicinity of an origin the records refer to forced vibrations, while at a distance the motion represents a periodic natural movement of the crust which varies with its heterogeneity. With regard to the second difficulty, now and then we have evidences that a disturbance recorded at a station far removed from an origin may be reinforced and lengthened by a repetition of the first disturbance which has reached the station by travelling in an opposite direction round the world. Generally, however, the record from a horizontal pendulum near to an origin appears to move as long as, if not longer than, a similar instrument at a distant station, which means that in certain instances the author's difficulty is non-existent. Finally, it must be borne in mind that a single impulse at an origin results in the birth of a series of waves which reach a distant station along different paths and with different speeds, with the result that a blow at an epicentre may at a distance from the same be recorded as a long train of waves.

When Major Dutton suggests to his readers that the Seismological Investigation Committee of the British Association carries on its work in consequence of financial aid received from the British Government, we recognise that he shares a widespread misapprehension.

Much is said relating to the elasticity of rocks, in connection with which an elaborate table, the result of investigations made by Prof. Nagaoka, of Tokio, is reproduced. A second long table is that drawn up by M. Montessus de Ballore relating to the distribution of seismicity.

The illustrations, of which there are sixty-three, are for the most part excellent, but there are one or two photomechanical reproductions of instruments which we imagine will give more delight to their authors at the sight of their own shaky caligraphy than to the ordinary reader.

Taken as a whole, the work is one to be read by all who wish to know what is known respecting the propagation of wave motion in our earth since the invention of the seismograph, and it is destined to receive a hearty welcome.

TECHNICAL MECHANICS.

Die technische Mechanik: elementares Lehrbuch für mittlere maschienentechnische Fachschulen und Hilfsbuch für studierende höherer technischer Lehranstalten. By P. Stephan, &c. Erster Teil: Mechanik Starrer Körper. Pp. viii+344. (Leipzig: Teubner, 1904.) Price 7 marks.

IN the very early part of this excellent work there is a certain lack of system, inasmuch as, although the author very properly treats first of the equilibrium of a *particle,* he assumes the nature of the stress exerted in such rigid bodies as the bars of a framework, the crank and connecting rod of an engine, &c. The nature of such forces is never properly appreciated by the student who is truly a beginner in the subject of dynamics—and, indeed, there is no part of statics in which students of even very considerable experience are so apt to go wrong as that relating to the forces exerted by jointed bars. The author treats from the outset the equilibrium of forces acting in space of three dimensions without having previously disposed of the simpler two dimensional case, a course which meets with the approval of many teachers, although it seems to the reviewer to be the less simple method. Herr Stephan enunciates the parallelogram law for the composition of forces (or vectors generally) at the outset, and assumes it as a result of experiment—which, on the whole, is perhaps the wisest plan for a teacher. Near the end of the book, however, he gives the ordinary Newtonian proof of the proposition.

He gives very early and very clearly the method of determining the resultant of a system of coplanar forces acting on a body (other than a particle) by means of the force and funicular polygons—a subject in which English students are, as a rule, extremely weak. There is a section on the determination of the centres of gravity of all the bodies usually figured in our